TETA TO-0018
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TEST EFFECTIVENESS TREND OBSERVATION

Trend of Defects Observed During Galileo Assembly Level Dynamics Tests*

CONCLUSION:

Based on Galileo experience, assembly level dynamics testing detects primarily design defects followed by workmanship defects and manufacturing defects.

DISCUSSION:

An extensive review of the Galileo assembly level dynamics testing anomaly history, as documented by Problem Failure Reports (PFR's), was performed to establish the relative effectiveness of assembly level dynamics tests in detecting design (D), workmanship (WK), and manufacturing (MFG) defects.

The table below summarizes the dynamics environments PFR's written on Galileo for the 1986 launch opportunity. The total number of PFR's written is 66, however, three PFR's written on the Star Scanner assembly are counted as one, since they document an identical failure occurring in three different axes during the same test. Table 1 lists the problen/failures by cause code and test level.

	Cause Code *	Qual/PF	FA	Total
Failures	*Design*	22	8	30
	Workmanship	7	3	10
	Manufacturing	4	1	5
	Sub total	33	12	45
Problems	*Other*	6	13	19
	Total PFR's	39	25	64
	Total Tests	160	92	252

*Cause Code does not always correspond to that listed on PFR

Table 1 - Galileo Dynamics Assembly Tests PFR's

*This trend report analysis is just Galileo dynamic test effects. A survey of other test performance is planned to shed additional insight into these effects. A revised trend report, if appropriate, will be issued when the survey is completed.

The PFR data in Table 1 were separated into two primary categories: *Failures and Problems*. PFR's are classified as a failure if a defect was brought out by the dynamics test and the assembly subsequently required redesign/rework. Those PFR's classified under *Problem* report anomalies such as *data out of specification, changes in telemetry functions, changes in test specification*, etc., and were dispositioned "Use As Is." Those PFR's classified as *Problems* had been considered failures in an earlier trend analysis report, TETA-006; reclassifying them has no significant impact on the conclusions from that report. Hereafter, the discussion will focus only on data from those PFR's documenting assembly failures.

Several observations can be made from the information in Table 1. The majority of assembly failures, 30 of 45, or 67%, were attributed to inadequate design. These are followed by failures due to poor workmanship at 22% (10 of 45) and manufacturing defects at 11% (5 of 45). Also, roughly 1-1/2 times as many failures per test occurred during Qual/PF (.21) than during FA (.13) testing. However, the ratio of Design to Workmanship failures during Qual/PF is roughly the same as for FA testing.

The assembly dynamics test failures are listed by test environment and cause code in Table 2. It can be seen from Table 2 that of the 22 design failures occurring during Qual/PF testing: 11 were uncovered by sine, 5 by random, 4 by either sine or random, and 2 by acoustic testing. Thus, sine vibration testing uncovered twice as many defects as random vibration testing; this is also the case for FA level testing. It is also interesting to note that, while random vibration testing uncovered a single WK/MFG defect, sine vibration testing revealed 7 WK/MFG defects. This differs from industry experience that indicates that random vibration is a more effective workmanship screen.

Assembly Failures	QualPF				FA			
Test Environment vs Cause Code	Design	Workmanship	Manufacturing	Total Testing	Design	Workmanship	Manufacturing	Total Testing
Sine Vibration	11	0	3	66	2	3	1	46
Random Vibration	5	1	0	66	1	0	0	46
Sine or Random*	4	6	1	0	5	0	0	0
Acoustic	2	0	0	14	0	0	0	0
Shock	0	0	0	14	0	0	0	0
Total	22	7	4	160	8	3	1	92

*Could not be determined if failure occurred during sine or random vibration

Table 2 - Dynamics Test Failures vs Test Environment

There are several possible reasons for the effectiveness of the sine vibration test: 1) the sine vibration is almost always the first dynamics test to which the assembly is subjected with the result that many failures occur before the fust random vibration is applied, 2) the launch transient events the sine is intended to simulate are the most severe environment for assemblies, 3) the designs were overly susceptible and needed to be more conservative, 4) workmanship/fabrication was inadequate, 5) the sine test is an overly conservative simulation of the transient environment, and 6) some combination of the above. Thus, the effectiveness of sine vibration testing, based on the Galileo data, may be overstated.